Junocam: approach and orbit 1 imaging. M. A. Ravine[1], M. A. Caplinger[1], C. J. Hansen[2], A. P. Ingersoll[3] and S. J. Bolton[4], [1]Malin Space Science Systems, 5880 Pacific Center Blvd, San Diego, CA, ravine@msss.com, [2]Planetary Science Institute, Tucson, AZ, [3]California Institute of Technology, Pasadena, CA, [4]Southwest Research Institute, San Antonio, TX.

Introduction: The Juno mission to Jupiter includes a visible/near infrared camera (Junocam) as part of its science payload. After a five-year cruise, Juno went into orbit around Jupiter on 4 July 2016. Junocam took images of Jupiter and its satellites in the weeks before Jupiter Orbit Insertion (JOI). After having been powered off for a week around JOI, Junocam was turned back on and has been imaging since then. As Juno is in a highly elliptical orbit, the images currently being taken are very low resolution, but show that the instrument is functioning well.

The details of the Junocam development have been documented previously [1]. Our purpose here is to summarize the aspects of the Junocam design relevant to interpreting the images, to present images already acquired and to describe the planned acquisitions for the next periapsis pass on 27 August 2016. During that pass, Juno will pass within 5000 km of Jupiter's cloudtops, with Junocam acquiring the highest resolution images ever taken of Jupiter.

Junocam imaging scheme: The Junocam camera head is fixed-mounted to the Juno spacecraft, with its optic axis pointed perpendicular to the spacecraft spin vector (Figure 1). The 58° wide Junocam field of view is thus swept though 360° by each spacecraft rotation.

Figure 1. The Junocam flight camera head, shortly after it was integrated with the Juno spacecraft.

The instrument can image in four different color bands by means of a fixed color filter array mounted to the Junocam CCD detector. Color images are built up by "pushframe" imaging, as is done with the MRO MARCI [2] and LRO WAC instruments [3]. The four color bands are shown in Figure 2. The three visible bands (blue, green and red) were selected to provide color images similar to what the human eye would see. The fourth band, which overlaps the methane absorption feature centered at 889 nm, was selected to provide images with some vertical discriminability (features that sit higher in the atmosphere have less of their light absorbed by methane in the band, and thus appear brighter).

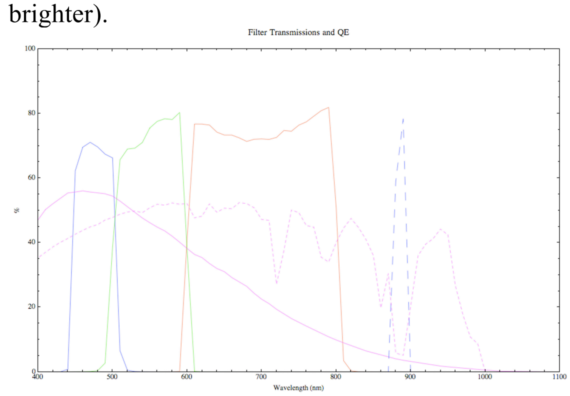

Figure 2. The bandpasses of the four Junocam color filter bands (blue, green, red and 889 nm methane). These are plotted over the quantum efficiency of the Junocam detector and the Jupiter spectrum. This shows the challenge of methane-band imaging, with the reflectivity of Jupiter becoming very low and the detector response likewise.

Because of the low light level at Jupiter—being five times farther from the Sun than Earth, the solar irradiance is twenty-five times lower than at Earth—Junocam incorporates two other features: a relatively fast lens (f/2.7) and the capability to clock the camera's interline transfer CCD detector to track the motion of the target from the rotation of the spacecraft (Time Delay Integration, or TDI). For imaging in the visible bands, only low levels of TDI (1 or 2) are required to get an acceptable signal-to-noise ratio (SNR). For the methane band, the signal levels are low and the instrument response is also low, so large amounts of TDI are required (up to 64 lines, the maximum the instrument can do). With these much longer exposures, the methane band images are more vulnerable to transient radiation hits.

Operations:

Approach. During the three weeks before Juno JOI, Junocam was turned on and acquired three-color visible images of Jupiter and the Galilean Satellites once every 15 minutes. Over 1300 color images were acquired between 12 and 29 June, which were then assembled into a movie of the approach to Jupiter (see https://www.missionjuno.swri.edu/). An example of one of these frames is shown in Figure 3. This sequence shows the satellites making multiple revolutions about Jupiter and going in and out of eclipse. While Jupiter is small enough to be almost featureless at the beginning, at the spacecraft nears the planet, the classic features become visible (the belts and zones, the Great Red Spot (GRS) and shadows of the satellites crossing the sunlight face of the planet. The raw images are also available for download from the Mission Juno website.

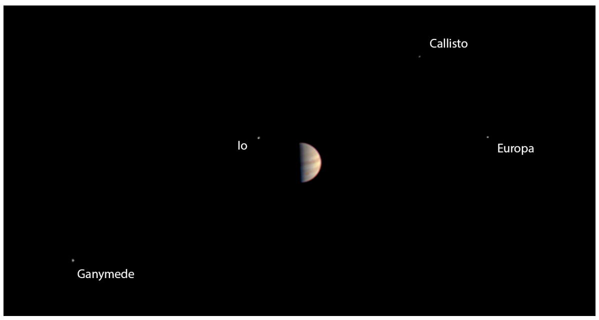

Figure 3. An approach image taken by Junocam of Jupiter and the four Galilean Satellites. The Great Red Spot is visible on the lower (southern) half of the planet (12 to 29 June 2016).

Orbit 1. Five days after JOI, Junocam was powered on and commanded to acquire images of Jupiter. While the spacecraft had passed within 5000 km of the planet during orbit insertion, by 10 July, it was 4.3 million km away. At that distance, although the resolution in the images is low, it was initially still better than the highest resolution of the approach images (see Figure 4).

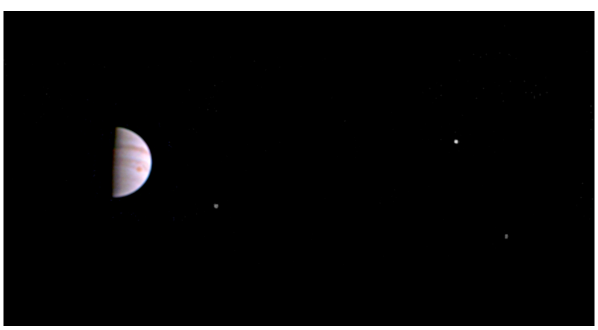

Figure 4. A Junocam image of Jupiter and the Galilean Satellites (excepting Callisto), taken three days after Jupiter Orbit Insertion. The Great Red Spot is visible south of the equator.

Methane band. Due to data volume constraints, no methane band images were acquired during approach. To determine the actual signal levels from Jupiter in this band, a series of images were taken in the methane filter with 32 lines of TDI. The signal levels were, as expected, somewhat low, but still high enough to discern the features we expected to see in this band: the polar haze, the equatorial band and the GRS. See Figure 5.

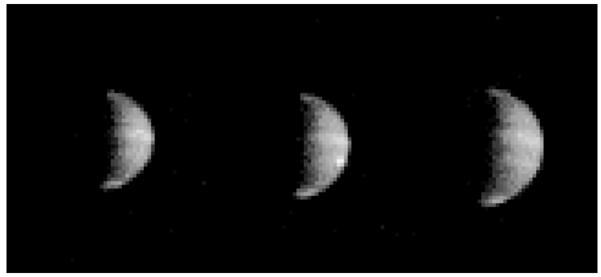

Figure 5. A sequence of three Junocam images in the 889 nm methane absorption band. The polar hazes and equatorial band are visible, as is the GRS in the center image.

First Periapsis (PJ-1). On 27 August 2016, Juno will make its first periapsis pass. Junocam will be on for this entire pass, and will acquire the following images (in priority order):

- Before closest approach, looking “down” on the north pole (RGB color and methane).
- After closest approach, looking “up” at the south pole (RGB color and methane).
- At closest approach, the highest resolution image ever of Jupiter (RGB color).
- An approach time-lapse sequence for the five days preceeding PJ-1.
- Ganymede (resolved but small).

Depending on the constraints of this sequence, we may also attempt long exposures of the poles to determine if Junocam has the capability to detect Jupiter’s aurora (the uncertainty is whether the aurora will be brighter than the scattered light from Jupiter in the Junocam wide-field optics in a long exposure).

References: [1] C. J. Hansen, et al. (2014) *Space Science Reviews,* [pp.1-32], doi:110.1007/s11214-014-0079-x. [2] J. F. Bell, et al. (2009) Mars Reconnaissance Orbiter Mars Color Imager (MARCI): Instrument description, calibration, and performance, *Journal of Geophysical Research-Planets* 114, E08S92, doi:10.1029/2008JE003315. [3] M. S. Robinson, et al. (2010) *Space Science Reviews*, [pp.81-124], doi:10.1007/s11214-010-9634-2.